FELLOW'S PAMPHLETS

MODERN ANTISEPTIC SURGERY

AND THE ROLE OF EXPERIMENT IN ITS DISCOVERY AND DEVELOPMENT

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PHILADELPHIA

DEFENSE OF RESEARCH PAMPHLET XII

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MODERN ANTISEPTIC SURGERY

And the Rôle of Experiment in Its Discovery and Development

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MODERN ANTISEPTIC SURGERY

AND THE RÔLE OF EXPERIMENT IN ITS DISCOVERY AND DEVELOPMENT

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The subject naturally divides itself into three parts: (1) the conditions before the introduction of the antiseptic method by Lister; (2) the means by which his system was discovered and developed, and (3) the conditions existing after the introduction of the method, i. e., at the present time.

My surgical life covers all three of these periods since I graduated in medicine in 1862, some years before Lister began his work. I have, therefore, fought my way from the horrors of the preantiseptic days up to the delights of the present antiseptic days.[1]

I. THE PREANTISEPTIC PERIOD

In my early surgical experience every accidental wound and every surgical operation (that is, an intentional wound) was followed by inflammation and suppuration, i. e., the discharge of "pus" or "matter." This was not only constantly expected as an unavoidable process of Nature and believed to be needful for healing, but was constantly realized. Hence the pus was called "laudable" pus! How well I remember forty years ago at the beginning of each winter's session when I was the assistant of the late Professor Samuel D. Gross, his turning to the orderly and saying to him, "To-morrow, Hugh, I shall lecture on suppuration. Go over to the hospital in the morning and get a cupful of pus for my lecture." Pus, mark you, was always "on tap," so to speak, though the little hospital contained only a dozen beds!

1. In this article I use the word antiseptic as the more popular one to include also the aseptic method.

Perhaps the best way to give the reader an idea of wound conditions at that time will be to describe an ordinary operation and its results. We will suppose that it is an amputation. The surgeon approached the operation with the clean hands of a gentleman. He usually wore an old coat covered with dried blood spots from previous service. His finger-nails very likely were long and no special attention was given to them. The instruments were taken out of a velvet-lined case and were as clean as ordinary table-knives would be. The operation was done without any preliminary cleansing of the skin other than to remove any visible dirt. If the knife happened to fall on the floor it was picked up, rinsed in a basin of ordinary water and used as it was. The marine sponges then always used were washed clean in ordinary water and used over and over again even after being saturated with foul pus. The blood-vessels were tied with ordinary silk; one end was cut short, the other one hung out of the wound. After an amputation of a fleshy thigh I have often seen 25 or 30 such "ligatures," as they are called, gathered into two bundles, one at each end of the wound. The flaps were then sewed together with an ordinary needle and thread and the stump dressed first with an old rag (which, however, would be ordinarily clean) or scraped lint spread with some simple grease. Over that would be placed some other rags, lint, cotton, or other dressing, and finally a bandage. During the Civil War these greasy dressings gave place to simple cold-water dressings.

By the second day the patient would begin to have considerable fever. By the third or fourth the temperature would rise to what we now know (for medical thermometers were not in general use in that early day!) to about 103, 104 or 105 F. Then we would poultice the wound. Every few hours the patient would be disturbed, a new poultice put on to replace the old one, now cold, foul and ill-smelling, and by this time bathed with pus. I have often seen the pus escaping by the tablespoonful and the wounds alive with squirming maggots resembling chestnut worms. By this time also it was hoped that the silk ligatures, with which the arteries had been tied, had literally "rotted" loose and each one of them was gently pulled on to the discomfort of the patient. Care was taken that the ligatures with knots tied on them (in order to distinguish those that secured the large blood-vessels) should not be pulled on severely

until probably the tenth or twelfth day. Meantime the patient was tossing about the bed with pain, with thirst, without appetite, without sleep except such as morphin would secure. This at the same time dried up all the secretions, producing constipation and other evils.

By about the tenth to the fourteenth day, suppuration having been fully established and quantities of pus pouring from the wound, the fever would subside and the wound would begin slowly to heal. Of course, the healing could not be complete so long as the silk ligatures were still protruding from the wound. Sometimes they did not become detached for even months or years, but more commonly all of them would rot loose in from ten days to three weeks. When the silk ligatures on the large blood-vessels came away, if the healing process had formed in the blood-vessels a firm clot, which had become adherent, and, so to speak, "corked" it up, all went well. But, as very frequently happened, when the ligature and the rotten end of the artery were pulled off and there was no clot to act as a stopper, "secondary[2] hemorrhage" followed. This often came on after the patient's wound had been dressed and the surgeon had left, and, if so, very likely the first notice that the nurse had that anything was wrong would either be the gasping for breath of the patient or his moans and cries, or sometimes by the blood which had not only saturated the mattress, but had even appeared in a pool on the floor. How fatal were such hemorrhages may be seen from the fact that in 2,235 cases of hemorrhage in the Civil War 61.7 per cent. of the patients died.[3]

I shall never forget one night about ten days after the battle of Gettysburg, when it was my business as "officer of the day" to attend to all emergency cases. That night I was called to five cases of secondary hemorrhage. To indicate what a difference there is between modern and ancient conditions, in the thirty-four years since October, 1876, when I began the practice of the antiseptic method, I have not seen as many cases of secondary hemorrhage as I treated in that one night.

It was a rare thing for any patient after such an operation to get well under three or four weeks, and it was not uncommon for healing to be delayed for three or

2. So called to distinguish it from "primary hemorrhage," *i. e.* the bleeding occurring at time of the accident or operation.

3. Med. and Surg. Hist. War of the Rebellion, Part 3, Surg. Vol., p. 765.

four months, so that, in spite of the great mortality, the wards of the hospitals were cumbered with convalescent patients. The rare case in which healing took place by "first intention," i. e., at once, was recounted as a triumph. To-day it is precisely the reverse. The case in which healing does *not* occur primarily and at once is regarded as a disaster.

But a prolonged convalescence was the least of the evils to which a patient was subject. A large majority of the wounds were followed by erysipelas, by lockjaw, or by blood poisoning, and hospital gangrene sometimes became a veritable plague. Gangrene in various forms during the Civil War was rife and often fatal. In 2,503 cases 1,142 patients died, a mortality of 45.6 per cent.[4] In one variety which was frequent, hospital gangrene, a simple flesh wound scarcely larger than the bullet which made it, became larger and larger till a hand would scarcely cover it and it would eat into the tissues until one could put half his fist into the sloughing cavity.

Of 505 cases of lockjaw (tetanus), 451 were fatal, a mortality of 89.3 per cent.[5] Pyemia or blood poisoning was terribly frequent and almost as fatal as it was frequent, for of 2,818 cases in the Civil War 2,747 patients died, or 97.4 per cent![6] When a joint was opened or wounded, the result was frequently either amputation or death, or not uncommonly amputation and death. Of 2,382 wounds of the knee-joint alone for which amputation was performed 1,212 patients died, a mortality of 51 per cent., and of 973 similar wounds for which amputation was not performed 591, or 61 per cent. of the patients died.[7]

Fractures, as most people know, are divided into two kinds: simple fractures in which the skin is unbroken, and compound fractures in which the broken bone protrudes through the skin. Simple fractures nearly always heal with relatively little pain and slight fever; but in the preantiseptic days when the skin was broken and the bone protruded two out of three patients with these compound fractures were sure to die.

Moreover, certain regions of the body were forbidden ground unless the surgeon were absolutely compelled to invade them. No one would open the head if he could

4. Ibid., p. 824.
5. Ibid., p. 819.
6. Ibid., p. 858.
7. Ibid., p. 367.

possibly avoid it. No one would dare to make an incision through the abdominal wall into the cavity of the abdomen unless a bullet or a dirk had gone before him and opened the way. The reason for our hesitation was that death stalked behind us.

How eloquent is the statement of Sir Samuel Wilks,[8] that "the change came home to me in an almost startling manner from what I witnessed in the post-mortem room. Some time before [i. e., before Lister's discoveries], when reading a paper on pyemia (blood poisoning), I had no difficulty in collecting 100 cases which had occurred within a very short time previously, when suddenly this terrible malady disappeared—it was gone never to return." So, too, lockjaw (tetanus), except in accidental cuts that have been neglected and have not received proper surgical care, has almost completely disappeared. Again, at the present day one practically never sees erysipelas after operations; and in order to find illustrations of hospital gangrene to show to my classes for the last thirty years I have had to rely on pictures from the Surgical History of the Civil War and other similar sources, for I have not seen a single case in private or hospital practice since I first adopted the antiseptic method in 1876.

II. THE DISCOVERY AND DEVELOPMENT OF THE ANTISEPTIC METHOD[9]

Neither time nor space will allow me to describe the many earlier steps. Schwann, in 1837, in studying putrefaction, reached the conclusion that it was not the gases of the air, especially the oxygen, as was then universally believed, that caused putrefaction, but organic particles which floated in the air and which could be destroyed by heat. In 1854 Schröder and Dusch showed that putrefaction did not occur in organic fluids in flasks if the air entering the flasks was simply filtered through cotton wool. Pasteur, in 1864, showed that it was necessary neither to heat the air nor thus to filter it, for if the air merely entered through a tortuous tube in which the dust could settle before it reached the fluid

8. Royal Com. on Vivisection, 1907-08, Q. 7,750.

9. See Lord Lister's Collected Papers, Oxford, 1909 (later reference to these Collected Papers will be indicated simply by "Lister, vol. —, p. —)," Brit. Med. Jour., Dec. 13, 1902. The Lister number celebrating the fiftieth anniversary of his receiving his degree, and Lister's Huxley Lecture in the same journal, Oct. 6, 1900, and Cameron's "Lister and the Evolution of Wound Treatment, etc.," Glasgow, 1907.

no change took place in the fluid, or if flasks containing a material which would putrefy were left open in a place where the air had been undisturbed sufficiently long to allow the dust to settle, as, for example, in a cellar, no decomposition took place and no growth appeared in such fluids.

Lister naturally was profoundly impressed by these studies of Pasteur and he proceeded to make many experiments to confirm or disprove them. Among them I will only relate the following:[10] Lister filled four glass flasks one-third full of urine and drew out the neck of each flask with a spirit lamp into a tube less than one-twelfth of an inch in diameter. Three of these long open tubes were then bent at various angles downward, while the fourth, equally narrow, was left short and vertical. Each flask was then boiled for five minutes, after which they were left with the ends of the small necks still open. Through these open mouths the air, including its oxygen, would pass out during the heat of the day and pass in during the colder night. The boiling was to kill any organisms in the liquid or on the sides of the glass. The object of the bending of the three necks downward was to allow the air to pass in and out, but to intercept the particles of dust, which, according to the germ theory, caused putrefaction. The germs, being heavier than air, could not rise in the bent necks. The fourth neck, however, being short and vertical, not only allowed the air to pass in and out, but gave a very narrow but real opportunity for dust and germs to fall into the liquid. If any of these were living organisms they could produce putrefaction. In a short time the vessel with the short and vertical neck showed growths of mold and the liquid changed its color, showing chemical changes; but in the three flasks with bent necks the urine *after four years was entirely unaltered.* A year after the commencement of the experiment a little of the urine in one of the flasks with a bent neck was poured into a wine-glass; it had not lost its original acidity and normal odor and a microscope showed not the minutest organism. In two days it was most offensive, and under the microscope already teemed with organisms. The other three flasks were subjected to a further severe and rather amusing test. Two years after the beginning of the experiment Lister

10. Lister: ii, 173; Brit. Med. Jour., 1871, ii, 225.

had to transport them from Glasgow to Edinburgh on the railway when he was appointed to the chair of surgery in Edinburgh. He took charge of these flasks himself, "nursing them carefully," as he says, "to the amusement of my fellow travelers." In the drive from the station to his house the violent rocking of the carriage churned up the contents of the flasks till the upper part was full of a frothy mixture of this proved putrescible liquid with the atmospheric gases; yet after two years more no decomposition had taken place.

The explanation of this convincing experiment was simply this: The germs in the atmosphere could not rise against gravity in any of these tubes bent downward and so could not gain access to the urine. This easily preserved a decomposable fluid for four years, although the air passed in and out freely every day. But the urine in the flask with the straight but very narrow neck in a few days had undergone decomposition. The only difference between the flasks was that the three bent tubes prevented the entrance of the germs, though not of oxygen or other constituent of the air, while the straight but equally narrow tube allowed the germs to enter through in very small quantities, and yet these few grew and produced putrefaction.

In order still further to confirm this experiment, however, Lister tested these bent tubes by the condensed beam of light which Tyndall had used and found that they were optically empty.[11]

These experiments convinced him that it was not the oxygen or any other gas in the air that caused inflammation and suppuration, but that these were caused by *the minute organisms suspended in the air.* In dressing a wound, then, the problem was how to exclude not the air or its oxygen, which was impossible, but how to exclude the organisms in the air. This could be done by applying a dressing saturated with some material capable of destroying the life of these germs. This was the basis of the antiseptic method.[12] It must be remembered that at that time we were wholly ignorant of what now everybody knows, that there are hundreds of different kinds of germs or bacteria. Even the greatest scientists were then groping in the dark seeking for the light by observation and especially by experiment.

11. See Tyndall's charming lecture on Dust and Disease, in Fragments of Science, 1871, p. 275. Appleton & Co.
12. Lister: ii, 37; Brit. Med. Jour., 1867, ii, 246.

About that time Lister was much struck with an account of the effect of mingling phenol (carbolic acid) with the sewage of the town of Carlisle, England.[13] He proceeded, therefore, to experiment with it in compound fractures. I have already stated how fatal a compound fracture was in those days. Indeed, Mr. Syme, the great Edinburgh surgeon, predecessor and father-in-law of Lister, was inclined to think that, on the whole, "it would be better if in every case of compound fracture of the leg amputation were done without any attempt to save the limb." The marked success which followed his dressing these compound fractures[13, 14] with carbolic acid led him then to experiment with its use in abscesses.[13, 14, 15] This was followed again by such remarkable success that he was led to try it in accidental wounds and finally to intentional and extensive wounds, i. e., surgical operations.[16]

Practically the progressive introduction of the antiseptic system from compound fractures up to deliberate surgical operations was one vast experiment in the human living body—an experiment justified, as all the world well knows, by its splendid and continuing results. Yet when in 1880 or 1881 Lister wished to make additional experiments on animals to perfect his method still further, so stringent was the law in England that he was obliged to go to the Veterinary School at Toulouse, France.[17]

Like many surgeons, Lister had noticed the fact that a needle or a bit of glass would often lie for an indefinite period in the body without producing inflammation or pus, but that a bit of silk or linen thread was sure to produce pus. He believed the reason was that the thread was porous and that its interstices contained these germs which no one had then seen and identified. and that they gave rise to decomposition and produced the pus. So, Lister, from his previous experiments with phenol (carbolic acid), believed that if the thread with which an artery was tied were steeped in phenol and both the ends of the silk were cut short it might be left in the wound without producing any inflammation or

13. Lister: ii, 3; Lancet, 1867, i, 326, 357, 387, 507; ii, 95.
14. Lister, ii, 3, 32, 37; Brit. Med. Jour., 1867, ii, 246.
15. Lister, ii, 32, 36, 42; Brit. Med. Jour., 1867, ii, 246.
16. Lister, ii, 188, 199, 256, etc.; Brit. Med. Jour., 1871, ii, 225; Edinburgh Med. Jour., 1871-2, xvii, 144; Edinburgh Med. Jour., 1875-6, xxi, 193, 481.
17. Lister, ii, 281; Lancet, 1881, ii, 863, 901; Tr. Internat. Med. Cong., London, 1881, ii, 369.

suppuration. The wound could then be closed at once—an immense gain, for it would heal at once. "Before applying these principles on the human subject," he says, "I though it right to test them on one of the lower animals."[18] Accordingly, Dec. 12, 1867, he tied the great blood-vessel in the neck of a horse, having steeped the silk for some time in a solution of phenol. Both ends were cut short, the wound was entirely sewed up and treated with phenol dressings. Ten days after the operation the dressings were removed, the wound was healed, and there was no pus! Thirty-nine days after the operation he carefully examined the artery which he had tied. The operation was a complete success, the blood current had been entirely arrested and the thread had been covered in by dense fibrous tissue. Thus encouraged, he says: "I felt justified in carrying a similar practice into human surgery."[19] Jan. 29, 1868,[20] he saw a woman, 51 years old, with an aneurism as large as a large orange in the upper part of the left thigh. (An aneurism, I should explain, is a dilated portion of an artery, the yielding of the wall being due to disease of the wall of the blood-vessel. This dilatation continues to increase in size till finally the wall of the artery is so thin that it bursts and the patient dies from hemorrhage.) On the following day he tied the woman's artery with a piece of silk which had been steeped for two hours in phenol.

The wound was treated like that in the horse's neck, i. e., both ends of the ligature were cut short, the wound again entirely closed and a phenol dressing applied. The patient was immediately relieved of the pain she had previously experienced; she had no fever, the pulse was practically normal the entire time, and "her appetite, which had been absent during the four weeks of agony that preceded the operation, returned two days after it."[21] She made a perfect recovery. November 30, ten months after the operation, she suddenly expired. Fortunately, Lister himself had the opportunity of making the post-mortem. He found that her death was due to the bursting of a similar aneurism inside of the chest. Examining the artery which he had tied, he found that

18. Lister, ii, 63; Lancet, 1867, ii, 668.
19. Lister, ii, 65; Lancet, 1867, ii, 668.
20. Lister ii, 88; Lancet, 1869, i, 451.
21. Lister, ii, 89; Lancet, 1869, i, 451.

the silk had almost all disappeared, but that there was a little fluid around the remnant of the ligature, which probably would have developed into a small abscess and might have caused great mischief had she lived longer. This, therefore, suggested to him the expediency of substituting for the silk some other substance which would be more readily absorbed.[21]

In Philadelphia years before Dr. Physick had already tried animal ligatures made of buckskin, Dorsey those of kid, Hartshorn had used parchment, and Bellenger and Eve the tendon of the deer, but for various reasons these had all been abandoned. Lister determined to try catgut. Although he had great confidence in the use of catgut steeped in a solution of phenol, yet he says[22] "in order to put the antiseptic animal ligature to the test, I made the following experiment," for only by experiment in an actual living body of animal or man could the question whether it was actually safe or not be surely answered. Dec. 31, 1868, he tied the right carotid artery in the neck of a healthy calf at several places with different kinds of animal ligature, including catgut. All were cut short except one end of the catgut, which was purposely left three-quarters of an inch long to determine what would become of this foreign material. The wound was completely closed and dressed. After ten days the dressings were removed and the wound found quite dry. Thirty days after the operation Lister says, on dissection, he was struck with the entire absence of any infection or inflammatory thickening in the vicinity of the blood-vessel. On exposing the artery itself he was greatly disappointed at first to find the ligature to all appearance still there and as large as ever. On more careful examination, however, he found that this apparent ligature was not the catgut ligature at all, but that this ligature had been transformed into bands of living tissue, making the artery not weaker, as silk often did, but stronger than ever at the point where it was tied. The knots had disappeared and also the three-quarters inch of catgut purposely left. Everything had been absorbed.

Even one not a surgeon can see what an enormous difference in rapidity of healing without inflammation, pain or other serious disturbance of the body this use of catgut with immediate total closure and healing of the

22. Lister, ii, 93; Lancet, 1869, I, 451.

wound provided. Before Lister, the old ligatures hanging out in bundles were always inviting infection, suppuration, erysipelas, lockjaw, blood-poisoning, hospital gangrene and death. No patient was absolutely safe till the wound was absolutely healed and this often required weeks or months. With the catgut ligature, both ends being cut short, the wound closed at once, and, the ligature being absorbed, the wound healed in less than a week, not uncommonly in three or four days, with little, if any, immediate suffering and without any ultimate danger of those many serious complications above mentioned. But no one not a surgeon can appreciate to the full the meaning of these brief words. While the patient made a smooth and speedy recovery without complications, the surgeon slept the uninterrupted sleep of the just, secure against wearing anxiety on account of sudden hemorrhage or insidious infection. The heart-breaking tragedies which often made the surgeon wish he were a hod-carrier or even in his grave are now but specters of a horrid past.

As I have said, we had no idea at first of the enormous variety and different characters of the germs. In his early studies on putrefaction, Lister spoke of them in a general way as "germs," because the various species of plants (for they are plants and not animalculæ) had not been distinguished. Now there are scores and even hundreds of known varieties. Many of these simply cause putrefaction or decomposition and are not in themselves capable of giving origin to any particular disease. Other varieties, each one of which causes a special disease and can cause no other disease, have been isolated and identified. Some of these germs cause medical diseases, with which I have nothing to do here. The germs of lockjaw, tuberculosis, anthrax (wool sorters' disease), erysipelas, glanders, etc., are among the most virulent foes with which the surgeon has to contend.

How have these been identified and how do we prevent their entrance into the system of the patient? The process is very simple to describe, but very complicated and difficult practically. Let us take the case of lockjaw for instance. A peculiar kind of germ, looking a good deal like a tack with a straight body and a large head at one end, was discovered by animal experiments by Nicolaier in earth and dust in 1884.[23] In 1889

23. Deutsch. med. Wchnschr., 1884, No. 52, p. 842.

Kitasato, the Japanese bacteriologist,[24] first obtained it in pure culture, former experimenters having failed because they did not know that it only grows well when oxygen is excluded.

But how do we *know* that this tack-like germ and it alone is the cause of lockjaw?

First, in a patient ill with lockjaw, this particular bacillus or germ must be discovered.

Second, a pure culture of it must be produced; that is to say, the tetanus bacillus must be separated from all other germs and cultivated by itself. Third, some of this pure culture of tetanus unmixed with any other germs whatever must be injected into an animal to see point-blank whether this particular bacillus will produce lockjaw. Fourth, from the body of this animal the same germ that was injected must be recovered. Fifth, with a pure culture of this recovered bacillus the cycle must be begun over again and completed sufficiently frequently to assure the experimenter that the connection between the disease and the germ is not accidental, but essential and invariable. Sixth, no other germ used in the same way must produce lockjaw.

In this same manner the germs that produce inflammation and suppuration, which are *the* ever-present danger to the surgeon, have been identified, and also, what is equally important, the places where they and many others exist. In this way we have determined the fact that, while there are some in the air, they are few in number and so constitute a small though a real danger. But the places where they are found and are most dangerous are on the skin and clothing of the patient, the hands of the surgeon and especially under his finger nails and at the roots of his nails, on instruments, dressings, silk, catgut, and other things used for ligatures; in fact, practically every material that one can think of. We know now how all-pervading they are. We know, too, that phenol (carbolic acid), corrosive sublimate and other chemicals, or that boiling for a certain time, or heating to a certain degree and for a certain time, will kill these germs. Thousands of such painstaking researches in test-tubes and by many other bacteriologic methods have been carried out all over the world by men either wholly unpaid, working for the love of truth and love of their fellow creatures, or paid but meager pit-

24. Deutsch. med. Wchnschr., 1889, No. 31.

tances. Then when a discovery seems to have been made comes the needful, the finally convincing, the unavoidable experiment—in a living body itself. The only question is should Lister have made this final test first on a horse and a calf, or on two human beings? Can any one with a sane, well-balanced mind hesitate as to the answer?

III. THE RESULTS

The results of the establishment of the antiseptic method have been so extraordinary as to be incredible were it not for ample testimony the world over. They have been already stated in part, but a few words more must be added.

At present before an operation is begun the patient's skin, the surgeons' and the nurses' hands are scrupulously disinfected, sterile gloves are usually worn and every person is clothed in a disinfected gown. The instruments, dressings, ligatures, everything that is to come in contact with the wound, is carefully disinfected. Disinfected gauze "sponges" are used once and then discarded.

It is almost impossible for any one not a surgeon to understand how different are the results from this radical change of methods. No change of climate from fierce mid-winter storms to lovely summer breezes or autumn golden harvest could be greater. Most wounds now heal within a few days, one might almost say without the patient's being sick. Compound fractures and opened joints heal as if there had been no break in the skin. Arteries can be tied anywhere without fear of secondary hemorrhage. The abdomen is now fearlessly opened.

A woman with an ovarian tumor no longer has an operation postponed until it is very dangerous but inevitable, but by early operation is relieved almost without danger, even from tumors so large as to weigh twice as much as the patient herself. When I was assistant to Dr. Washington Atlee in the late sixties, before the antiseptic period, two out of three of his ovariotomy patients died, yet he was the then most famous operator in America. Now any surgeon who loses more than five out of 100 is looked at askance by his colleagues, and many, many hundreds of cases have been operated on with a mortality falling even below 1 per cent. There is not an organ in the abdomen that has not been attacked; organs which formerly when diseased could

not be touched because death was almost sure to follow are now operated on every day. In fact as I once described it, the abdominal cavity is almost the surgeon's play-ground! The stomach, the intestines, the liver, the gall bladder, the pancreas, the spleen, the kidney, every organ is operated on, and with extraordinary success. Did space permit, a more detailed statement could be given, but it could scarcely be more convincing.

In obstetrics the same happy results have followed the introduction of the antiseptic method. Puerperal or child-bed fever, which not uncommonly used to kill one-half or two-thirds or even three-fourths of the women in the maternity wards of a hospital, now is practically unknown except in the neglected cases brought into the hospital at a late date, and the preantiseptic general mortality in maternity cases has been reduced from 10 per cent. or more to 1 per cent. and less. Brain tumors, abscesses and other diseases of the brain formerly inevitably caused death, for we never dared to touch them. Now the number of recoveries is very large. Compound fractures now have a mortality of 2 or 1 per cent. or less, instead of over 60 per cent. and now very rarely require amputation; and amputations formerly followed by death in one-half the cases have a mortality of 10 per cent. or less. In general, both the soldier and the sailor are provided with the first aid packet, which contains an antiseptic dressing. This has enormously diminished the mortality of wounds received in battle.

Perhaps no better evidence of the value of the antiseptic method in civil life can be adduced than the results in three hospitals. In Munich[25] the General Hospital was excessively unhealthy. Blood poisoning was very frequent and hospital gangrene, which had appeared in 1872, had become annually a more and more frightful scourge until 1874, when *80 per cent.* of all wounds that occurred in the hospital, whether accidental or inflicted by the surgeon, were attacked by it! At the beginning of 1875 Nussbaum introduced the antiseptic treatment. From then on till Lister's visit, presumably in the summer of 1875, *not one single case* of hospital gangrene had occurred and only one case of blood poisoning, and that a doubtful one. Erysipelas was rare and mild instead of being very prevalent and severe, and the convalescent wards, which formerly had been filled to

25. Lister, ii, 248; Brit. Med., Jour., 1875, ii, 769.

overflowing, stood practically empty. In Halle,[26] Volkmann was operating in an extremely unhealthy hospital in small, overcrowded wards, with the toilet rooms opening directly into them and a large drain running directly underneath. It was so bad that it had been condemned to demolition. After his introduction of the antiseptic method in 1872, no single patient suffering from compound fracture in which conservative treatment was attained had died either from the fracture or from a necessary amputation, nor was there a single death from secondary hemorrhage or gangrene. No case of blood poisoning had occurred for a year and a half, though 60 amputations had been done. Hospital gangrene had entirely disappeared and erysipelas was extremely rare and mild.

Perhaps, however, the most extraordinary success was obtained by Lister[27] in his own wards in Glasgow. Lister was professor of surgery in Glasgow from March, 1865, till the autumn of 1869, but in that brief period he introduced measures that were absolutely revolutionary. The Royal Hospital in Glasgow was overcrowded, and in some parts of the building the conditions were so frightful that the wards had to be entirely shut up for a time. Lister's own account of this is interesting. He says:

"A crisis of this kind occurred rather more than two years ago in the other male accident ward on the ground floor, separated from mine merely by a passage twelve feet broad, where the mortality became so excessive as to lead, not only to closing the ward, but to an investigation into the cause of the evil, which was presumed to be some foul drain. An excavation made with this view disclosed a state of things which seemed to explain sufficiently the unhealthiness that had so long remained a mystery. A few inches below the surface of the ground, on a level with the floors of the two lowest male accident wards, with only the basement area, four feet wide, intervening, was found the uppermost tier of a multitude of coffins, which had been placed there at the time of the cholera epidemic of 1849, the corpses having undergone so little change in the interval that the clothes they had on at the time of their hurried burial were plainly distinguishable. The wonder now was, not that these wards on the ground floor had been unhealthy, but that they had not been absolutely pestilential. Yet at the very time when this shocking disclosure was being made, I was able to state, in an address which I delivered to

26. Lister, ii, 250; Brit. Med. Jour., 1875, ii, 769.
27. Lister, ii, 124; Lancet, 1870, i, 4, 40.

the meeting of the British Medical Association in Dublin[28], that during the previous nine months, in which the antiseptic system had been fairly in operation in my wards, not a single case of pyemia [blood poisoning], erysipelas, or hospital gangrene had occurred in them; and this, be it remembered, not only in the presence of conditions likely to be pernicious, but at a time when the unhealthiness of other parts of the same building was attracting the serious and anxious attention of the managers. Supposing it justifiable to institute an experiment on such a subject, it would be hardly possible to devise one more conclusive.

Having discovered this monstrous evil, the managers at once did all in their power to correct it. . . . But besides having along one of its sides the place of sepulture above alluded to, one end of the building is coterminous with the old cathedral churchyard, . . . in which the system of "pit burial" of paupers has hitherto prevailed. I saw one of the pits some time since. . . . The pit, which was standing open for the reception of the next corpse, emitted a horrid stench on the removal of some loose boards from its mouth. Its walls were formed on three sides of coffins piled one upon another in four tiers, with the lateral interstices between them filled with human bones, the coffins reaching up to within a few inches of the surface of the ground. This was in a place immediately adjoining the patients' airing ground, and a few yards only from the windows of the surgical wards! And the pit which I inspected seems to have been only one of many similar receptacles, for the *Lancet* of September 25 contains a statement, copied from one of the Glasgow newspapers, that "the Dean of Guild is said to have computed that five thousand bodies were lying in pits, holding eighty each, in a state of decomposition, around the infirmary."

When to all this is added the fact that the large fever hospital was separated from the surgical hospital by only eight feet, that Lister's hospital of nearly 600 beds was cramped in area and almost always full to overflowing, and that he was operating, it might almost be said, in a charnal house, yet that those wards were continuously and conspicuously healthy and enjoyed for "three years immunity from the ordinary evils of surgical hospitals under circumstances which but for the antiseptic system were specially calculated to produce them,"[29] we stand convinced by such a huge unintentional experiment on man himself.

Were not results such as these sufficient to justify the experiments on animals as related by Lister himself and

28. Lister, ii, 45.
29. Lister, ii, 126; Lancet, 1870, i, 4, 40.

here quoted, by which such blessed relief has been brought to mankind?

What was seen in Glasgow has occurred all over the world. The surgical revolution of the last thirty years is the most momentous in the entire history of surgery. In every science—chemistry, engineering, botany, physics, electricity—the era of precise experiments has been the era when enormous and constant progress has been made. Medicine is no exception. We have closely studied disease by various observational methods, and clinical observation for two thousand years had slowly advanced our knowledge up to a certain point. Then experimental research, which employed methods of precision, varying conditions at will, noting the different results, and multiplying the experiments at will instead of waiting, it might even be years, until Nature's second experiment occurred, began its work; and in the past thirty years experimental research has produced a more fruitful harvest of good to animals and to mankind than the clinical observation during thirty preceding centuries.

But we are far from having attained perfection. In medicine and in surgery many problems of disease and death are still awaiting solution and can only be solved by the experimental method. A number of organs in the body are as yet inaccessible and others have functions of which we know little or nothing. Many operations ought to be bettered in method and in results. The causes of many diseases, such as cancer, scarlet fever, measles, whooping-cough, etc., are as yet unknown. To dispel all this ignorance and discover a cure for all these and other diseases is the earnest wish of wise and humane experimenters the world over. Shall the community aid these humane life-saving efforts, or shall they by restrictive legislation call a halt and let death slay our fellow creatures and especially our dear children? The answer is clear. It will never be other than an emphatic NO to the latter cruel course.

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